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Blast-Induced Tinnitus & Its Treatment Strategies

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Blast-Induced Tinn & Related TBI

1) Blast-induced trauma is the “signature injury” from war theaters.

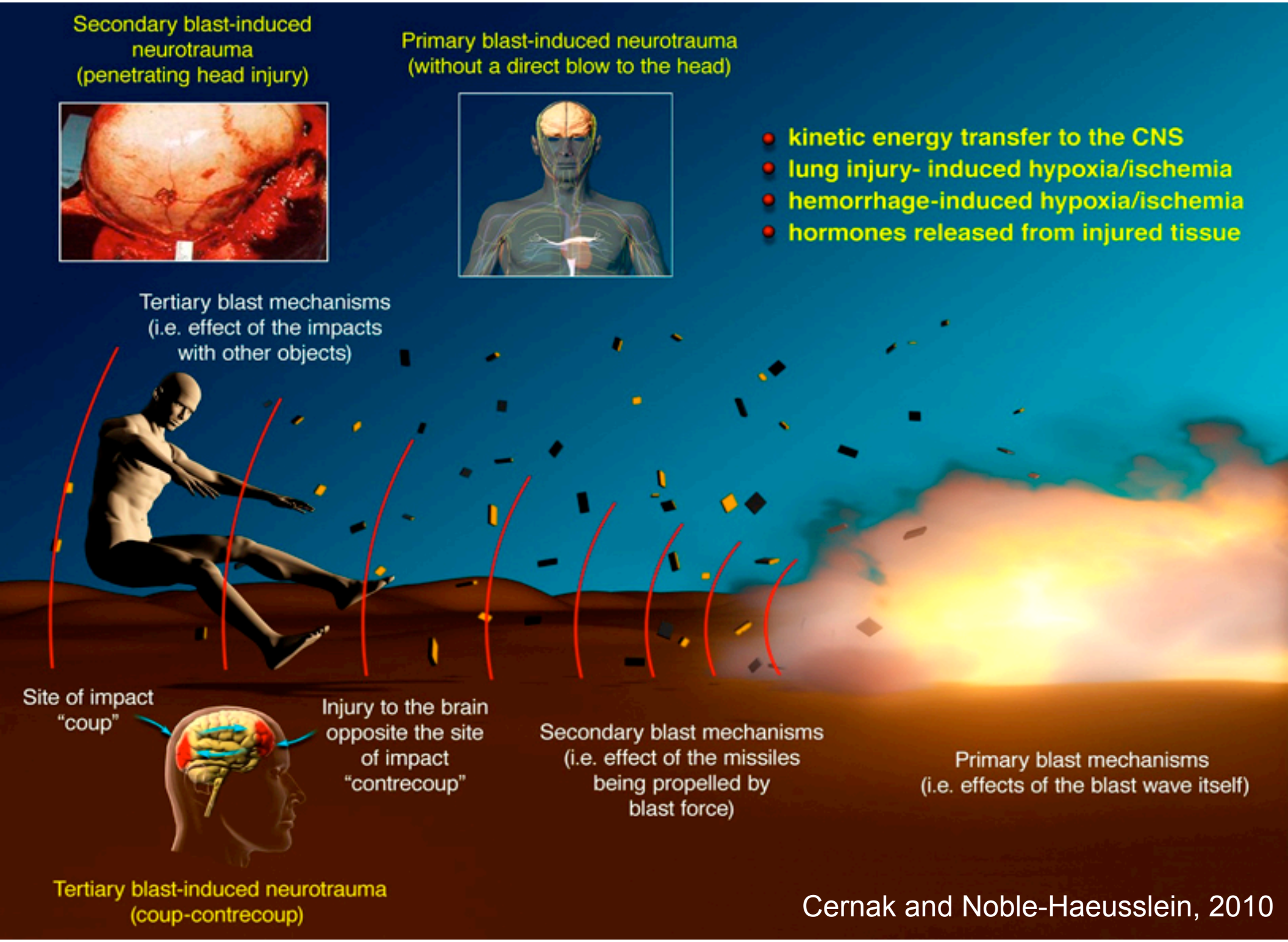
2) More soldiers survive bomb blasts due to improved armor & medicine. But blast often leaves soldiers with “invisible” mTBI.

3) Chronic tinnitus and hearing loss are the most frequent auditory-related co-morbidities.

4) Tinnitus along with post-traumatic stress can impact activities of daily living by producing:

Sleepless Nights,
Constant **Anxiety**,
Crazy **Mood Swings**,
Helpless **Depression**,
Energy Sapping **Exhaustion**,
Overall **Stress in Your Life.**

“The Ringing Just Won’t Stop!!!”



Cernak and Noble-Haeusslein, 2010

QUESTIONS & ISSUES

1) Noise exposure causes hyperactivity, hypersynchrony and plastic reorganization in auditory centers. However, the mechanisms and loci subserving blast-induced tinnitus and related TBI are unclear.

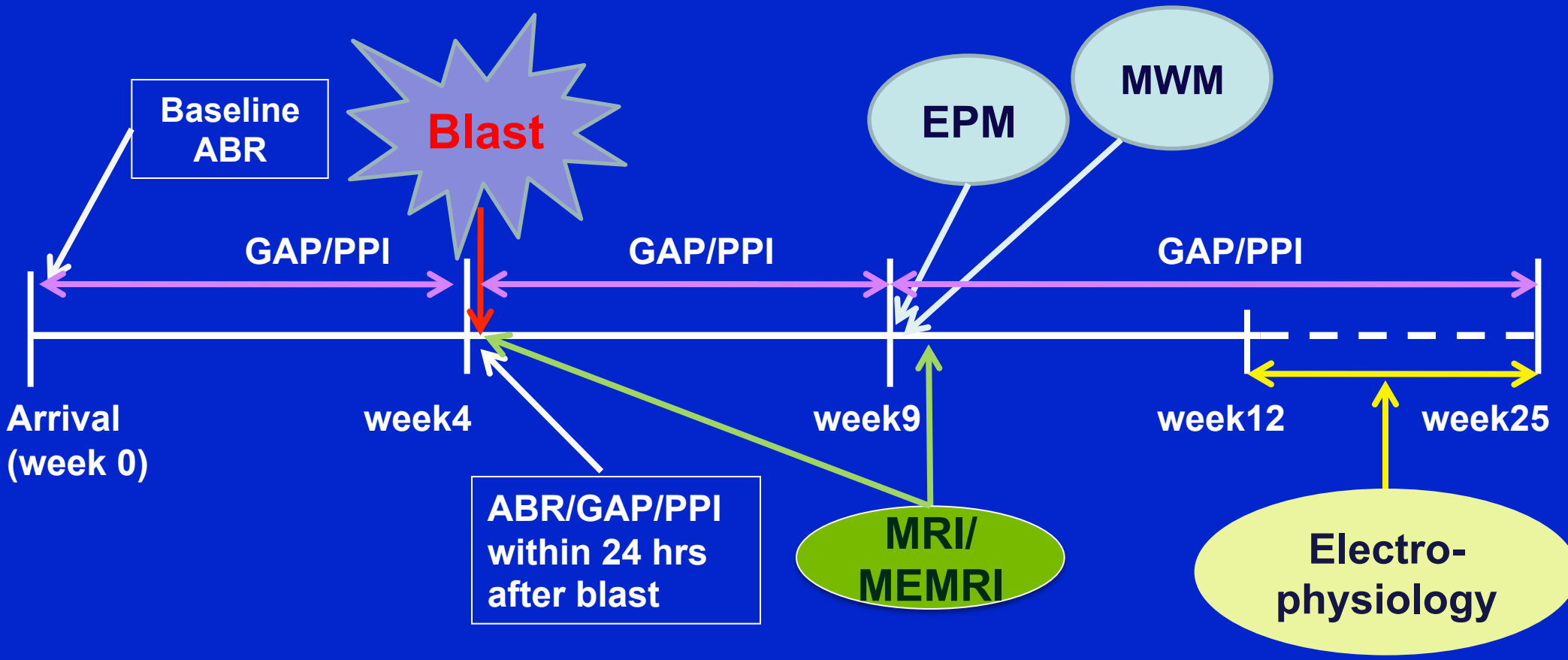
2) The development and persistence of tinnitus is compounded by brain mechanisms associated with HL, hyperacusis, and cognitive problems associated with anxiety, emotion and fear. Need to address the associated cognitive status and psychological state.

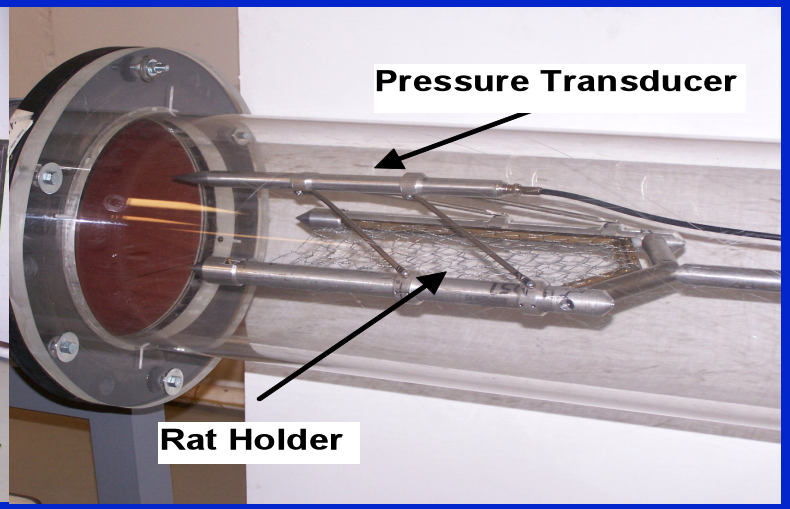
HYPOTHESES

1) Given that blast-related injuries cause damage to air- and fluid-filled sensory structures in the ear, the resulting degeneration of the AN triggers a cascade of anatomical, electrophysiological, and neurobiochemical plasticity in auditory pathways that could cause “tinnitus”.

2) Shock waves can yield direct shearing impact to the brain, which could also induce tinnitus through TBI-induced neuroplasticity.

Experimental Schedule

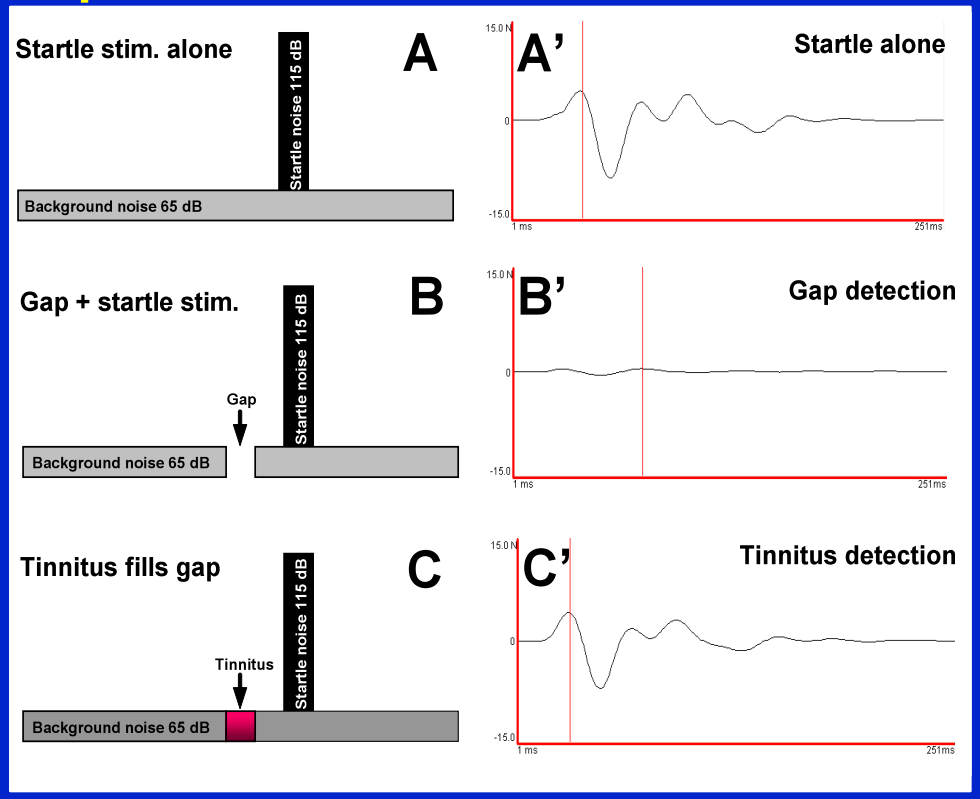


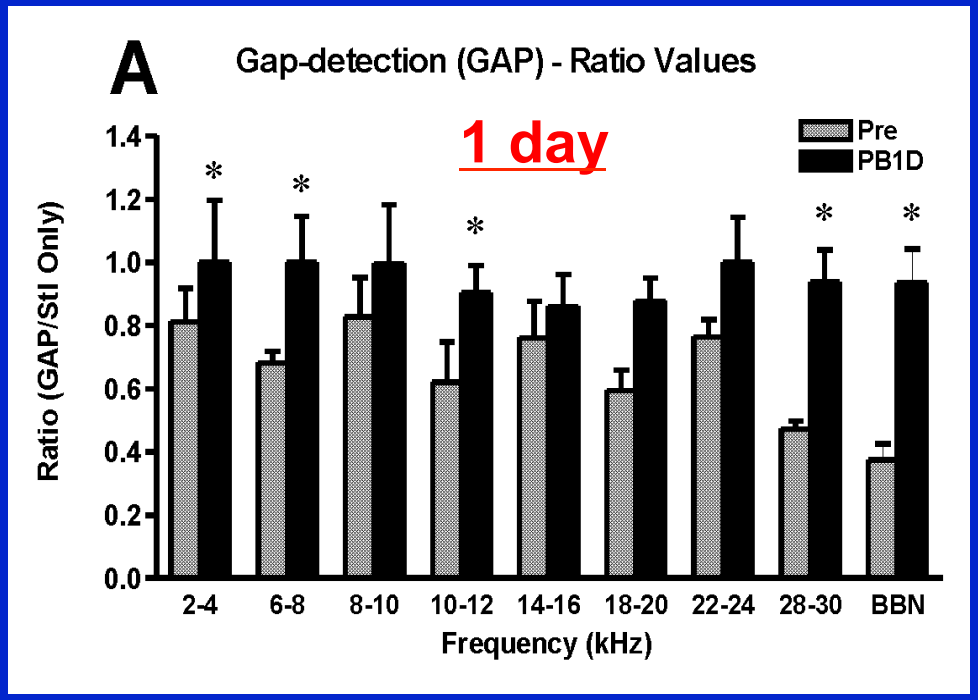


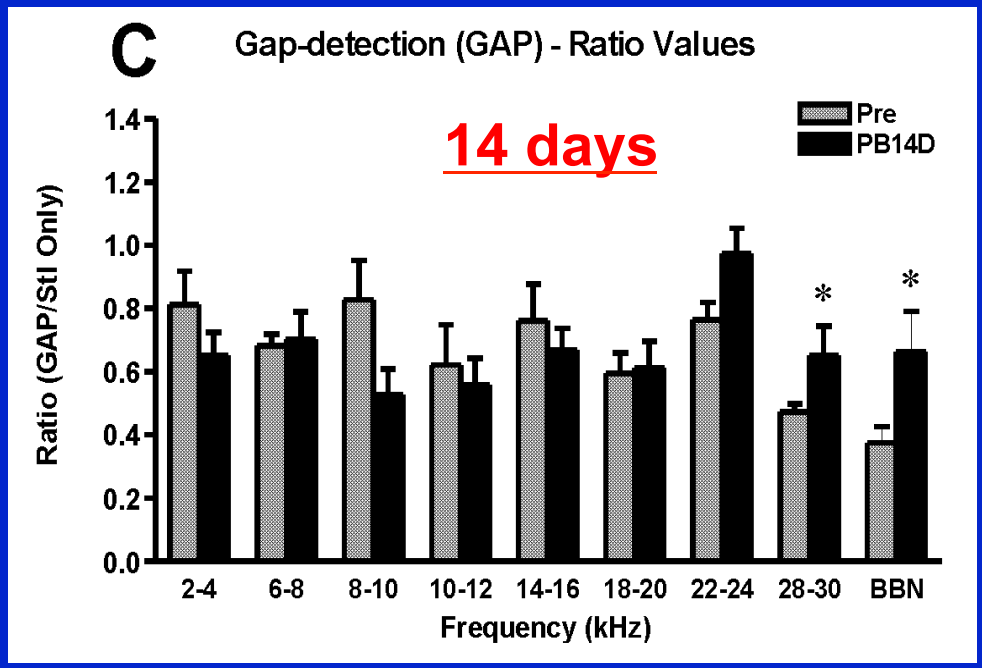
Gap-ASR

Blast-Induced Tinnitus

Mao et al. (J Neurotrauma, 2011)



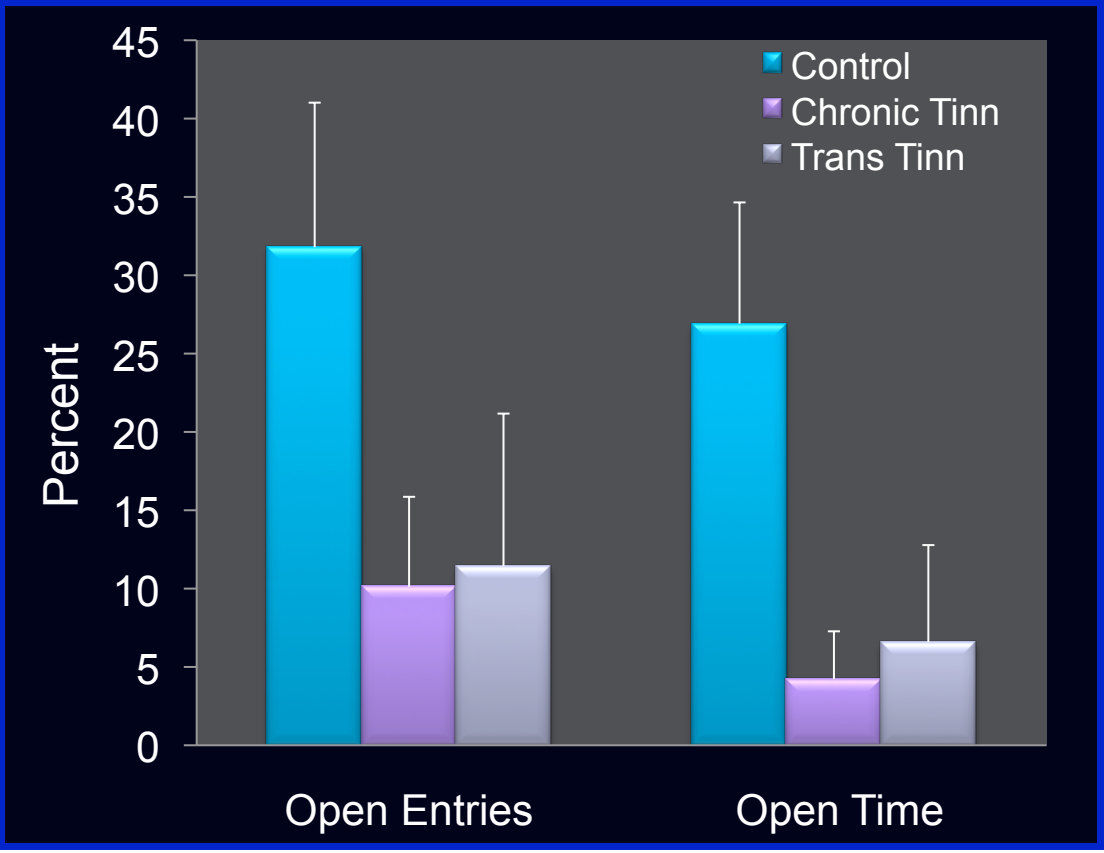


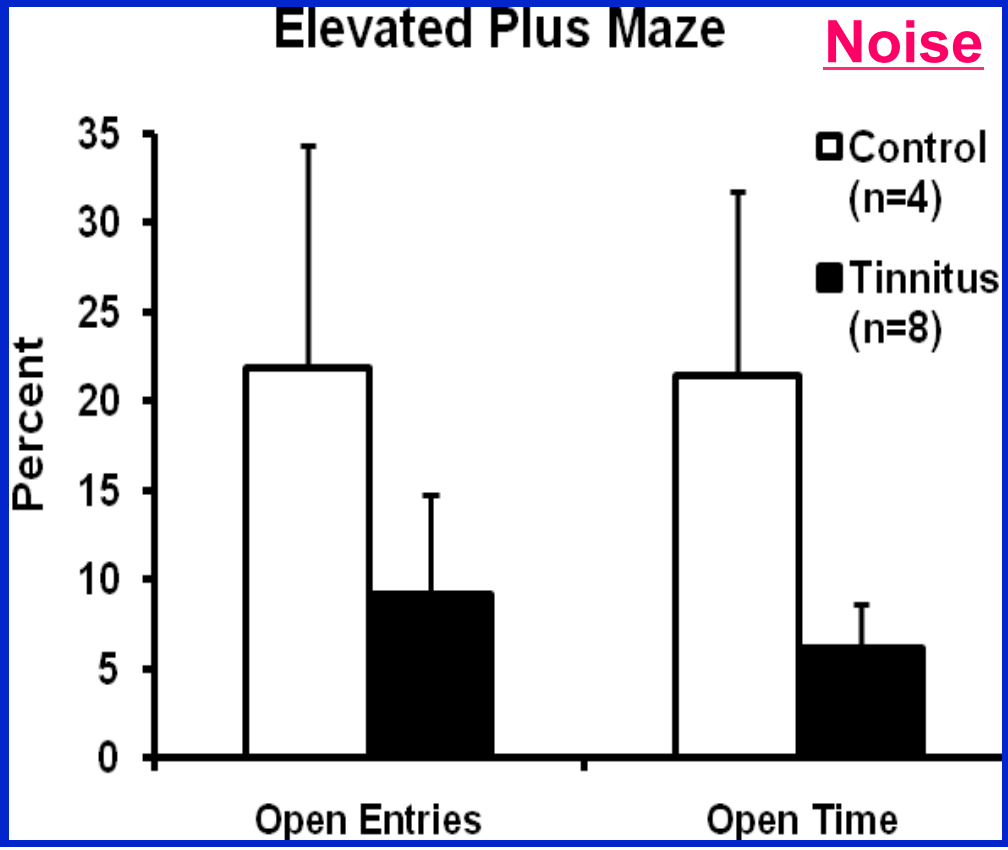


Tinnitus: 30, 90 days

Elevated Plus Maze - Anxiety

- Each animal was handled 5 days x 3 min/day prior to testing.
- Acclimated for 3 hours in the lab.
- 5 min in the maze
- Lighting:
  - 1.5 lux in open arm
  - 0.09 lux in closed arm

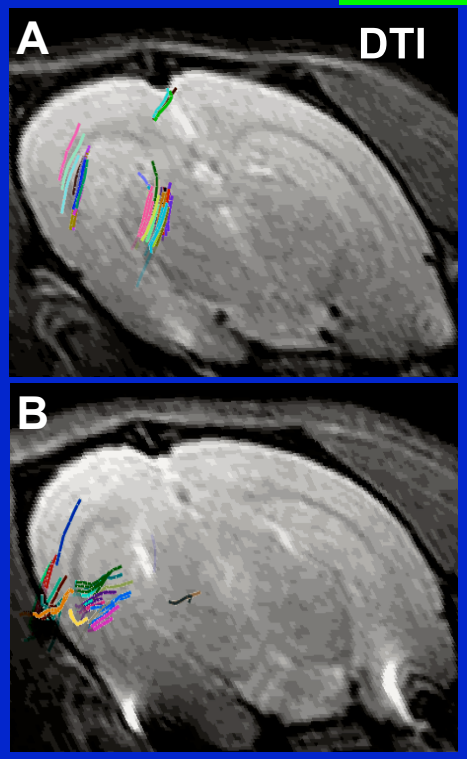


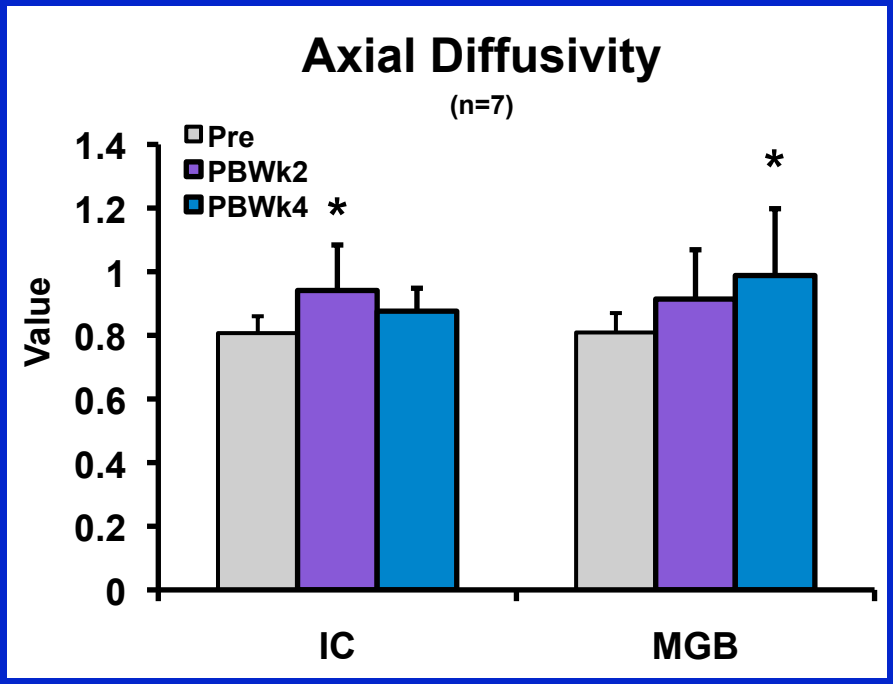


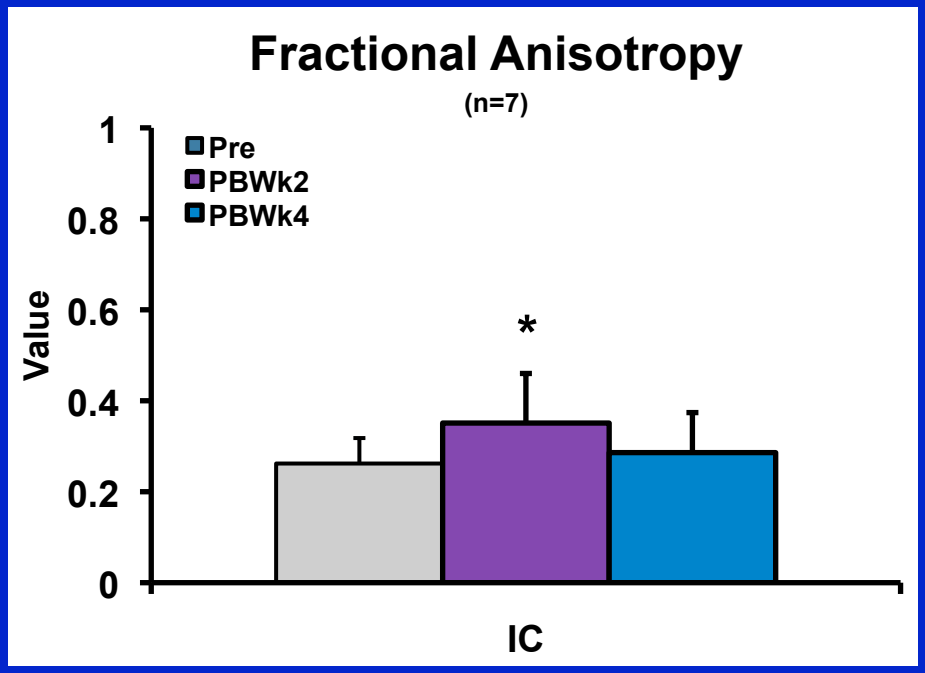
I. MRI Imaging

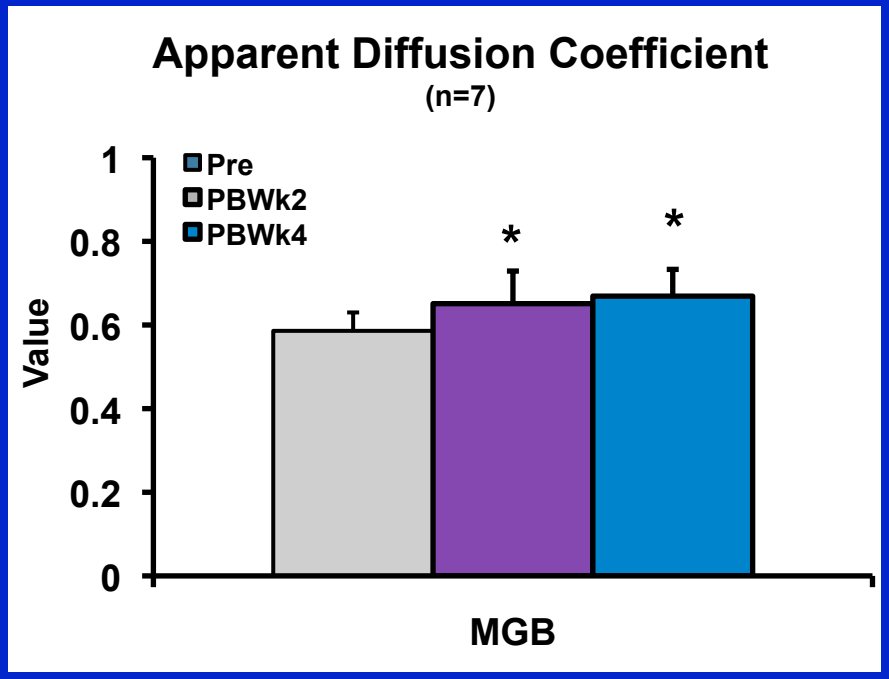
Post-Blast MRI-DTI

Mao et al., (J Neurotrauma, 2011)



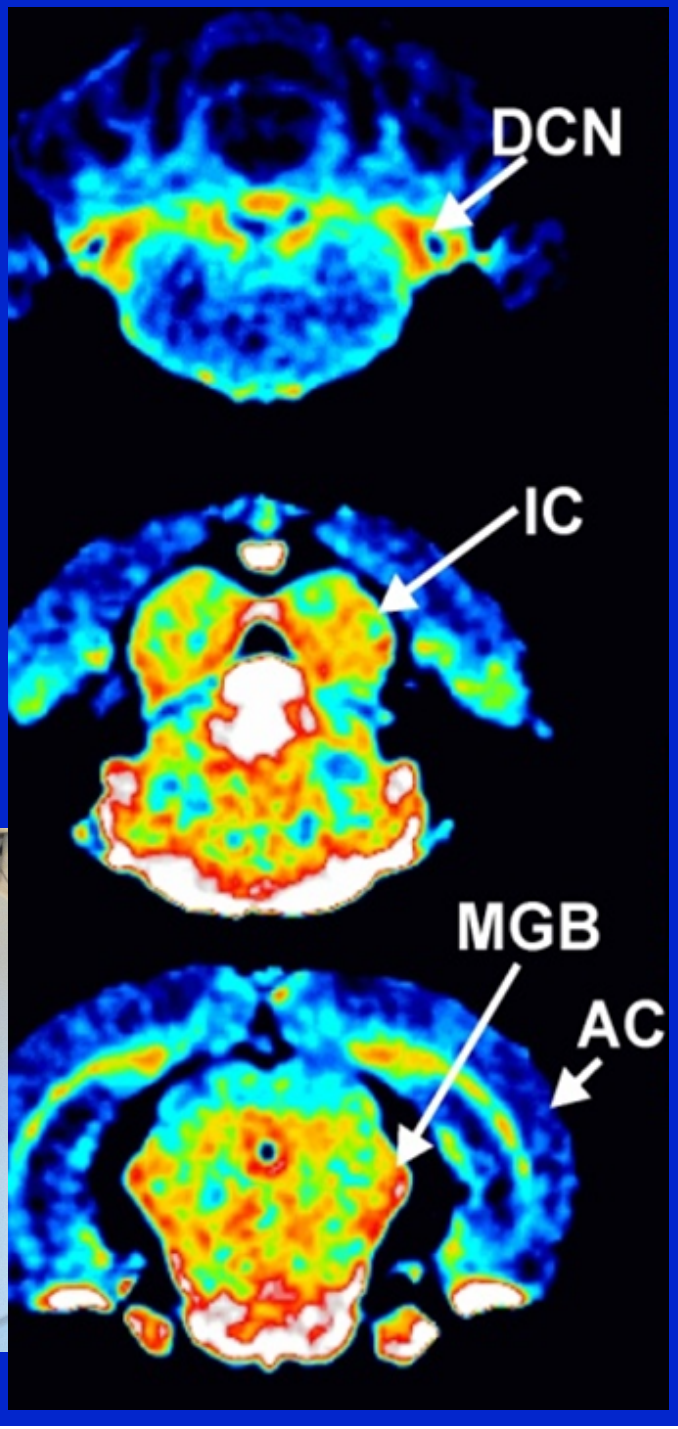


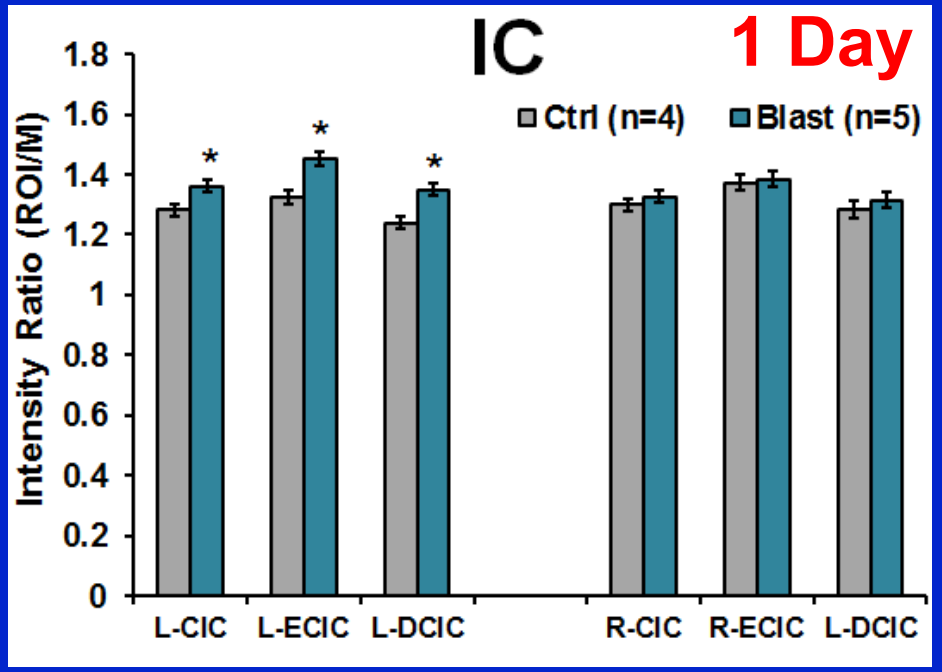


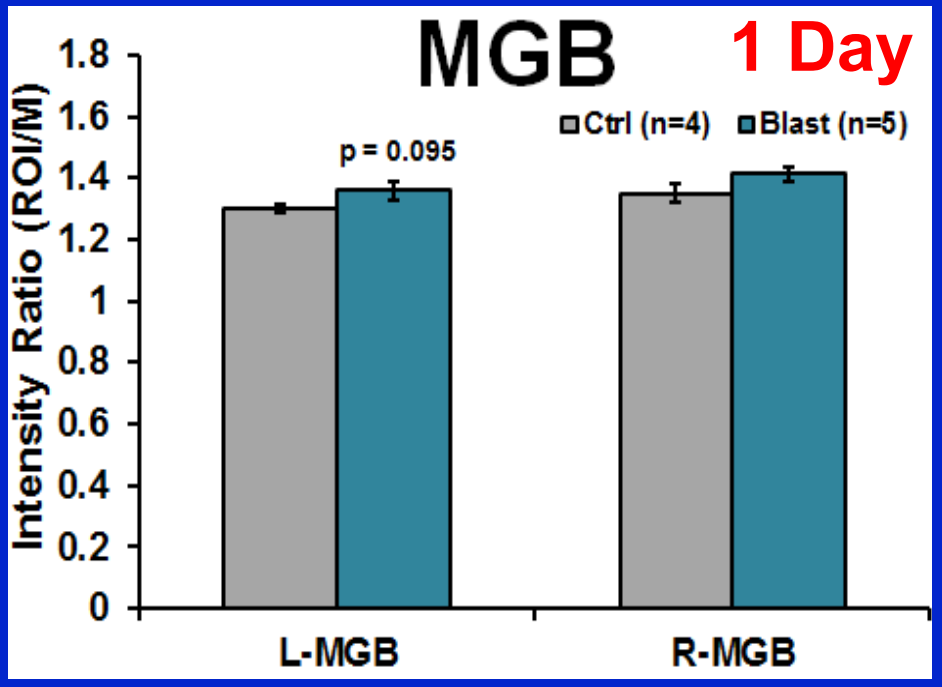


Post-blast MEMRI – Mn2+ accumulation

Jessica Ouyang







DISCUSSIONS & SUMMARY

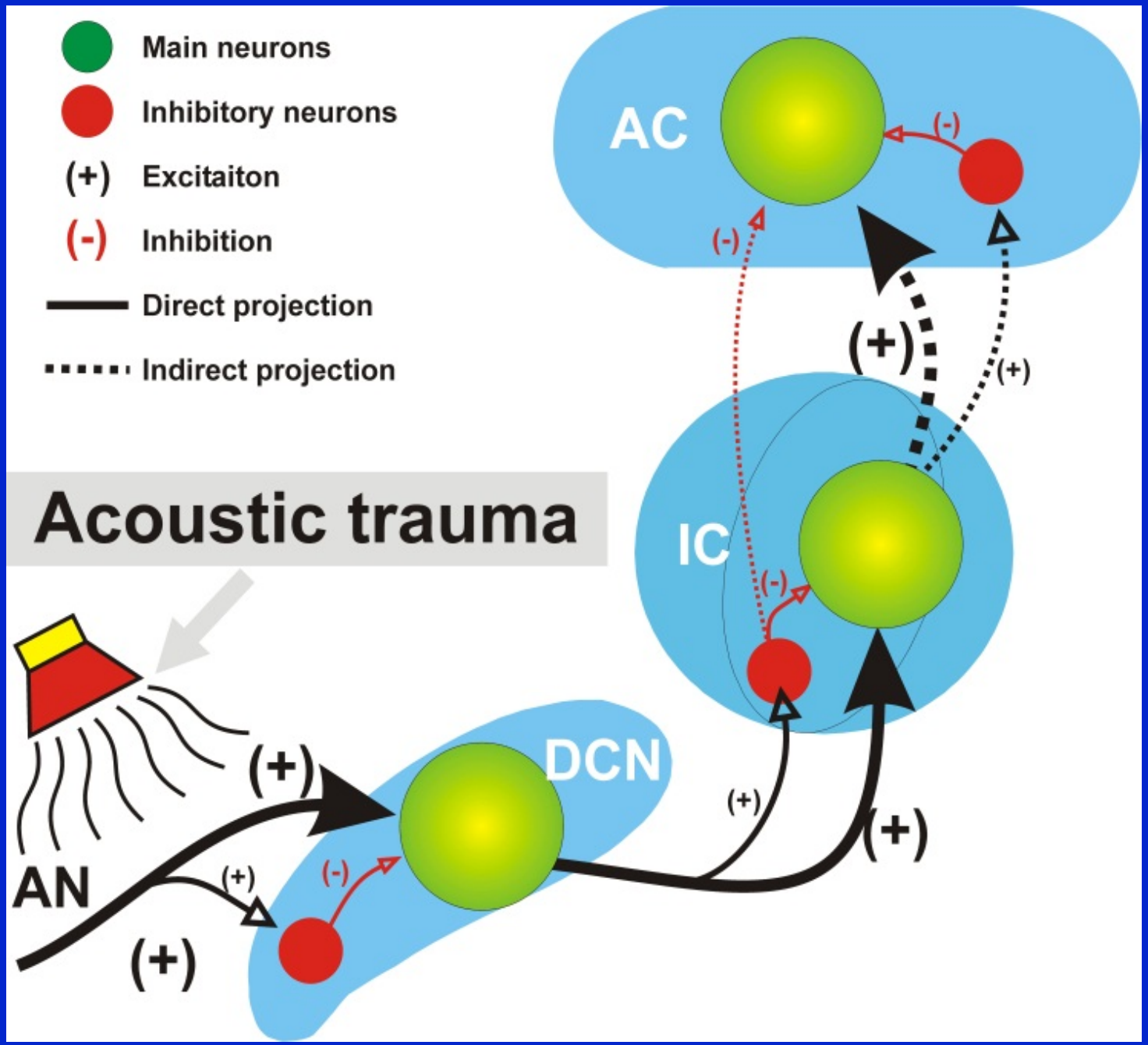
1) Single blast exposure induced early-onset tinnitus at multiple frequencies, which converged towards high-Hz region over time. The induced tinnitus was accompanied by hearing impairment, enhanced anxiety, and mTBI.

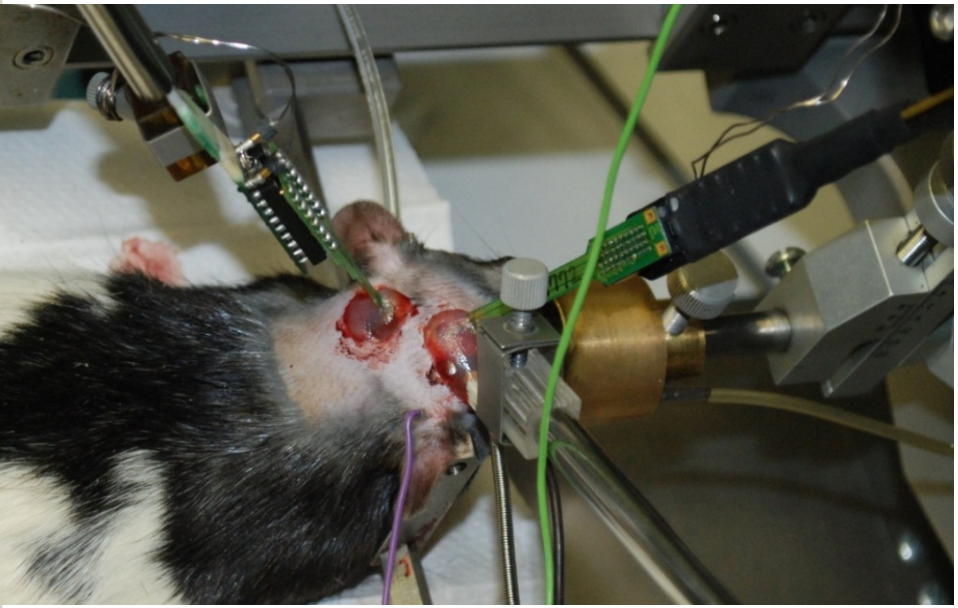
2) Blast-induced DTI changes and Mn2+ increases in the IC and MGB at early times suggest that tinnitus may be subserved by plasticity in the auditory brainstem and thalamus.

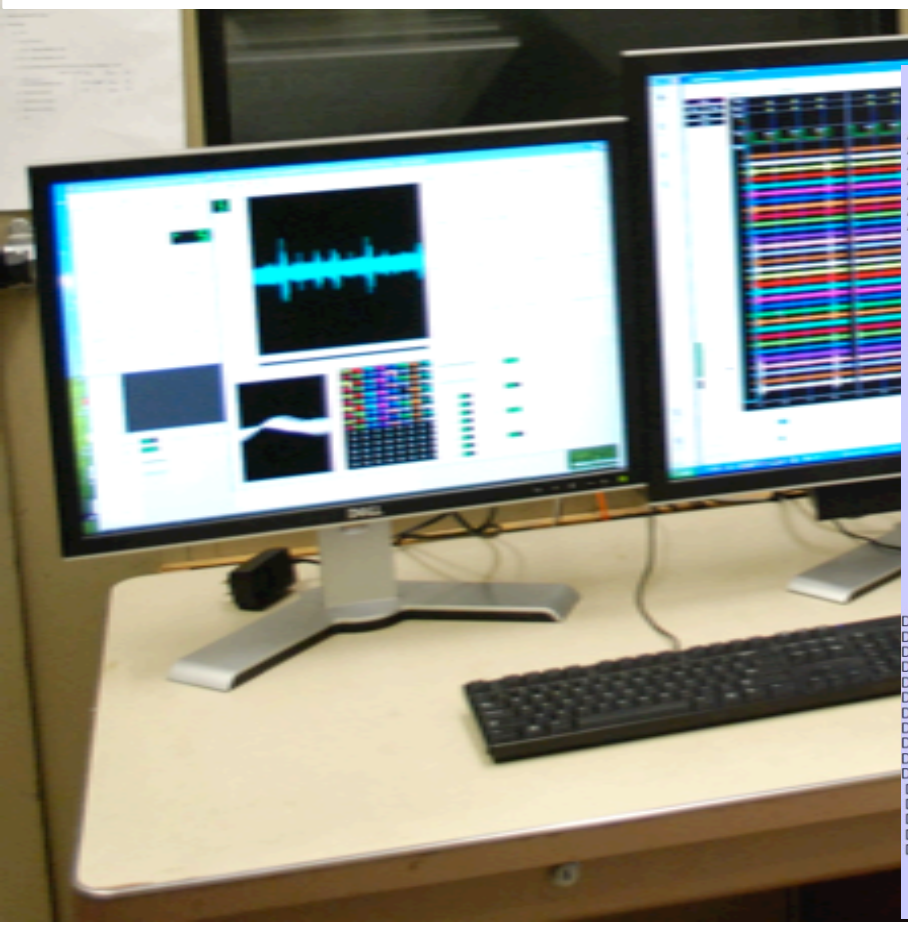
3) Following injury, both degenerative and compensatory processes are involved, possibly resulting in the no apparent change in the CN. Mn2+ increases in the AC and changes in non-auditory centers take longer time to appear, involving in chronic tinnitus.

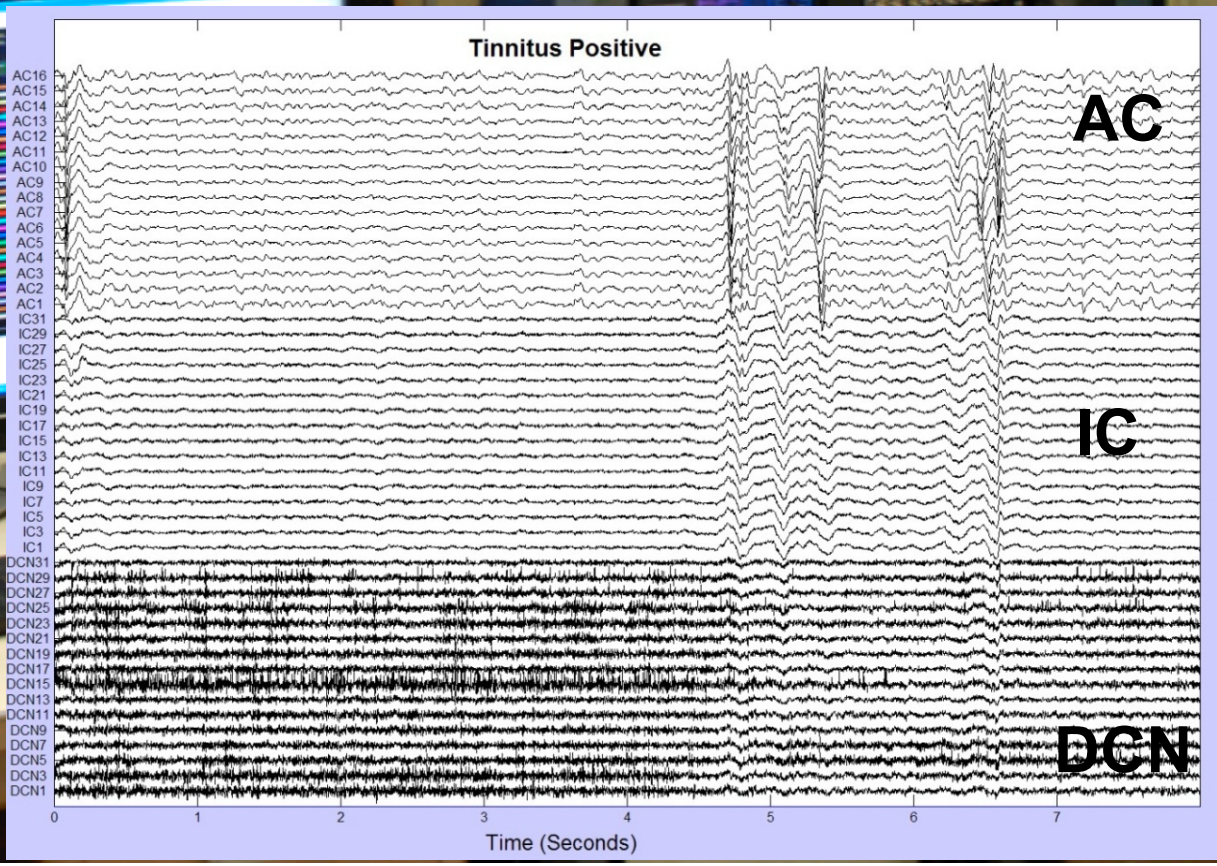
II. Electrophysiology

Neural correlates of tinnitus





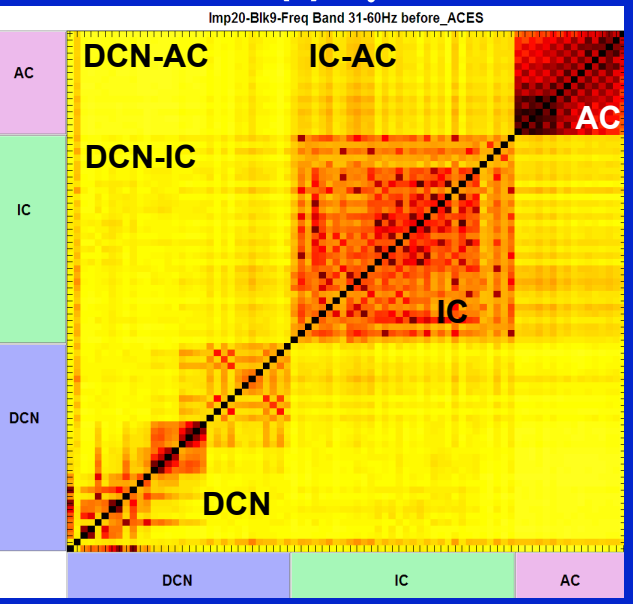



Tinnitus Positive
AC16
AC15
AC14
AC13
AC12
AC11
AC10
AC9
AC8
AC7
AC6
AC5
AC4
AC3
AC2
AC1
IC31
IC29
IC27
IC25
IC23
IC21
IC19
IC17
IC15
IC13
IC11
IC9
IC7
IC5
IC3
IC1
DCN31
DCN29
DCN27
DCN25
DCN23
DCN21
DCN19
DCN17
DCN15
DCN13
DCN11
DCN9
DCN7
DCN5
DCN3
DCN1
AC
IC
DCN
0
1
2
3
4
5
6
7
Time (Seconds)

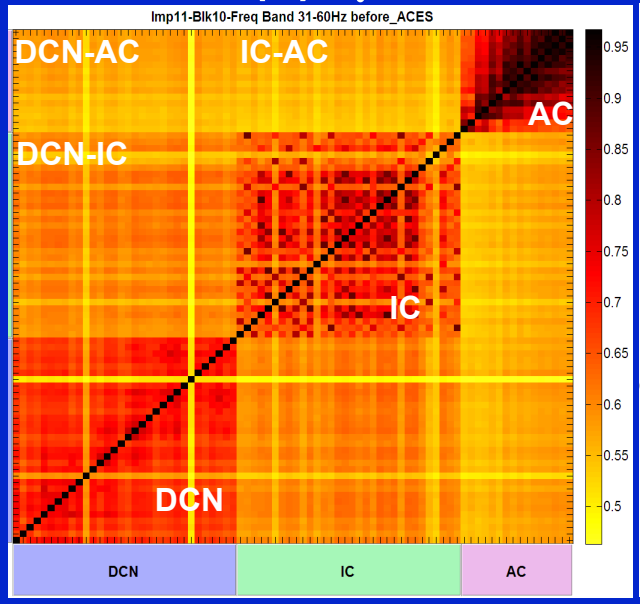
Post-Blast Electrophysiology

Coherence (30 days)

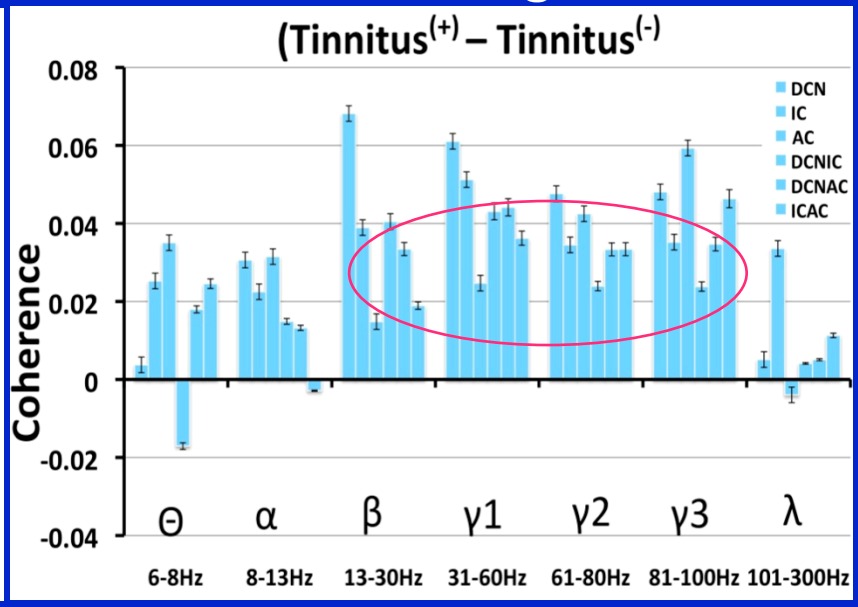
Tinni(-) γ band



Tinni(+) γ band



Net changes



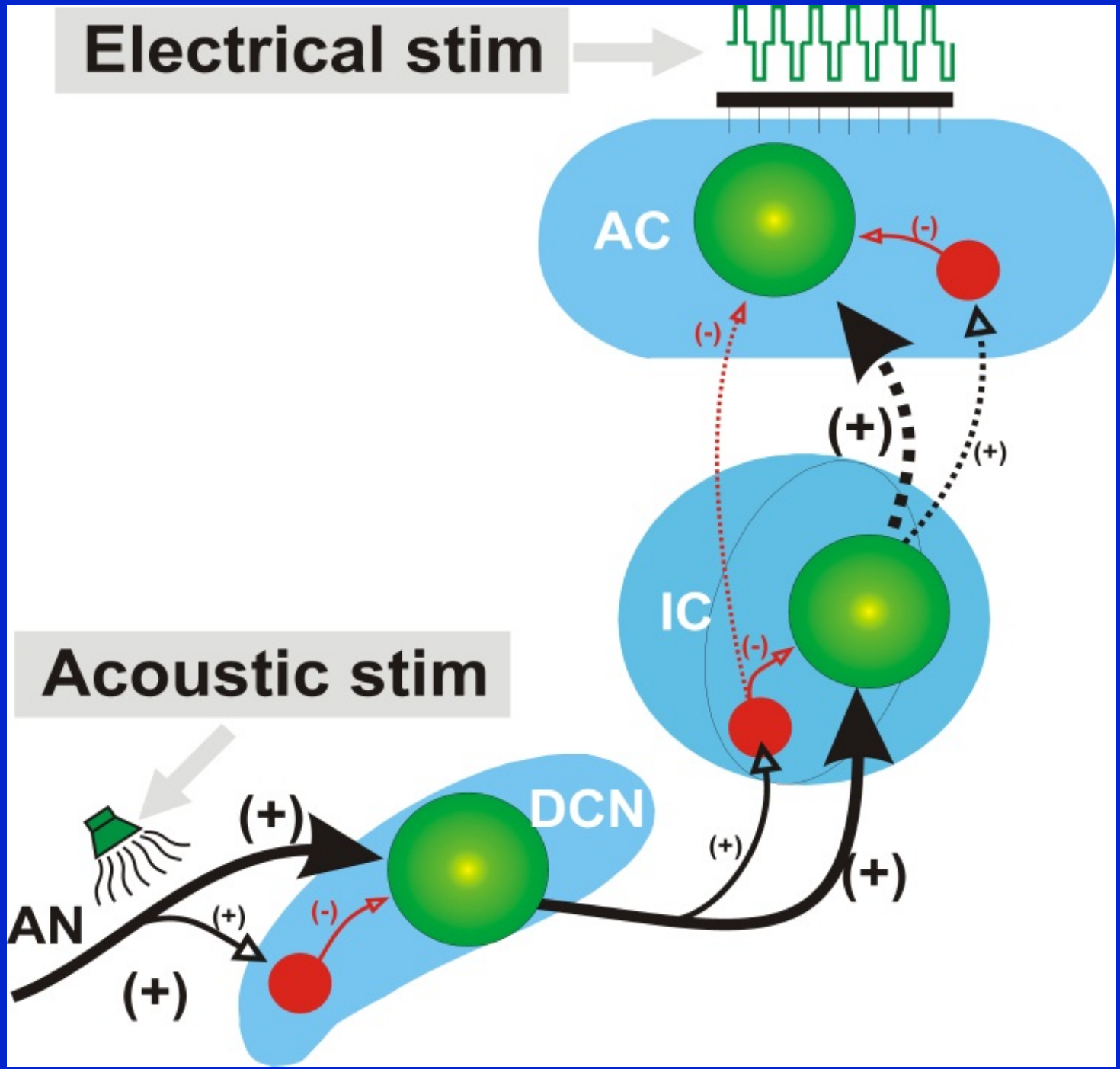
Increased coherence at broadband especially γ band activity within and among the DCN, IC and AC appears to be consistently associated with tinnitus.

III. Treatment Strategies

Treatment strategies for Tinnitus

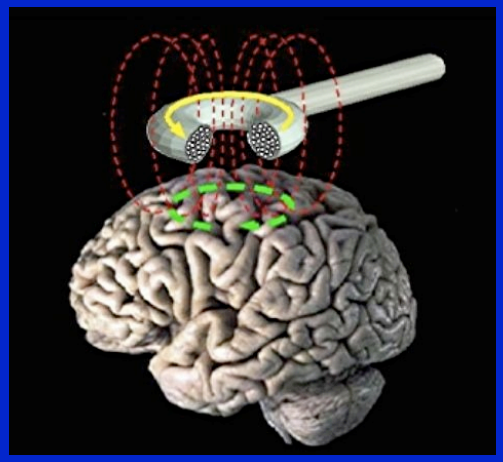
Auditory — **Link** — **Non-Auditory**

Neuromodulation to suppress tinnitus



Clinical evidence

Repetitive Transcranial Magnetic Stim (rTMS)



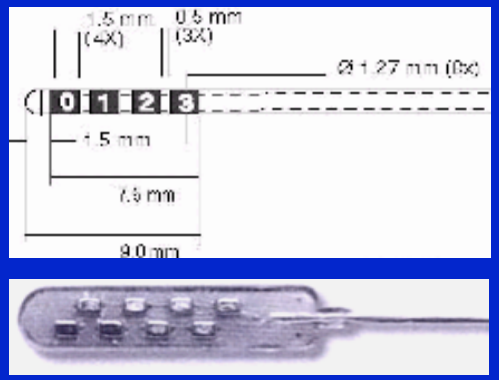
Limitations:

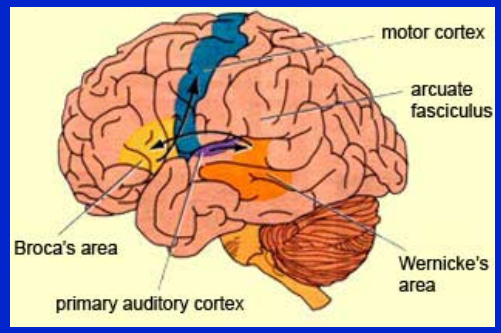
- Nonspecific stimulation (larger than AC, 33-96 cm^2) (Jalinous, 91)
- Limited penetration into brain tissue (Plewnia et al. 03)

Auditory Cortex E-Stimulation (ACES)

Advantages & Limitations:

- Better suppression with focal stimulation
- Large variability





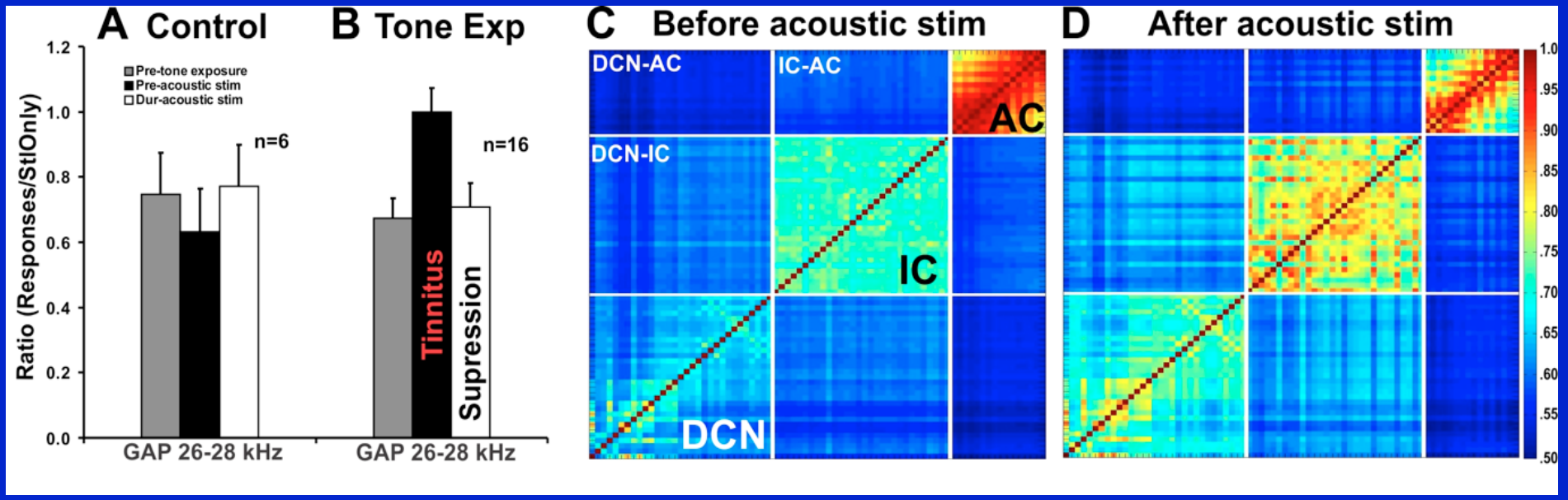
Transcranial Direct Current Stimulation (tDCS)

Vanneste et al., 2011

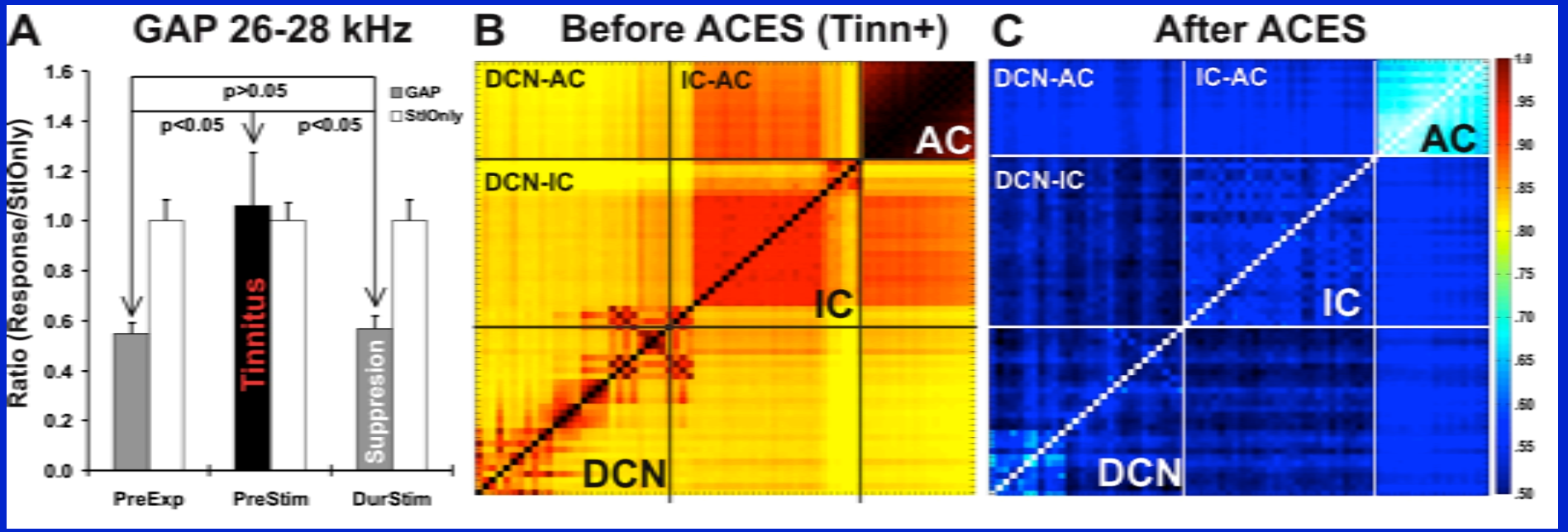
Acoustic (bottom-up) modulation

(10-18 kHz, 50 dB SPL)

Kwong, Zhang (2010)



ACES (top-down) modulation



Zhang et al. JARO, 2011

THANK YOU